and alſo to place the leaver exactly in the center. By which means there has been no alteration required ſince they were firſt fixed; and the engine continues to work as even, and true as it is poſſible.

I have applied wheels for reducing friction to ſome other engines with great advantage, which I ſhall take the liberty of laying before the Royal Society ſome other time; and fear I have treſpaſſed too much on their patience already by this long detail.

XXIX. *The Difference of Longitude between the Royal Obſervatories of* Greenwich *and* Paris, *determined by the Obſervations of the Tranſits of* Mercury *over the* Sun *in the Years* 1723, 1736, 1743, *and* 1753: *By* James Short, *M. A. F. R. S.*

Read June 2, 1763.

IT will, no doubt, appear ſurprizing, that I ſhould attempt to determine the difference of longitude between two of the moſt celebrated obſervatories in Europe; and in which ſome of the greateſt aſtronomers, that ever lived, have, for above eighty years, been conſtantly obſerving the motions of the heavenly bodies: yet it is moſt certain, that, to this day, we are ignorant of the ſaid difference of longitude: the Engliſh aſtronomers reckoning it to be $= 9' \; 20''$, and the French ſetting it down at $9' \; 10''$, which, they tell us, was found

found by M. Caſſini, by obſervations of the eclipſes of Jupiter's firſt ſatellite made by him, whilſt in London in the year 1698: we are no where told, that I know of, by what obſervations the Engliſh aſtronomers have fixed this difference at 9′ 20″.

In the Memoirs of the Royal Academy of Sciences at Paris, for the year 1734, there is an account given of thirty-three correſponding obſervations of the eclipſes of the firſt ſatellite of Jupiter, made at Greenwich and Paris, from the year 1677, to the year 1701: The mean of theſe thirty-three obſervations gives the difference of longitude between Paris and Greenwich = 9′ 29″.

I had lately the honor to deliver to this Society, a paper concerning the parallax of the Sun, determined by the obſervations of the late tranſit of Venus: In that paper I took notice that obſervations of the tranſits of Venus and Mercury over the Sun, have always been looked upon by aſtronomers, as very proper for determining the differences of longitudes between the places where ſuch obſervations have been made. I have calculated, and it may be demonſtrated, that, if we compare the obſervations of the late tranſit of Venus made at Greenwich, and by M. de la Lande at Paris, and ſuppoſe that the difference of longitude between theſe two places is = 9′ 25′, it will follow that the Sun and Venus are at an infinite diſtance, which is abſurd. Again, if we ſuppoſe the difference to be greater, it will follow, that the Sun and Venus are more than infinitely diſtant, which is likewiſe abſurd. We are therefore certain, if theſe obſervations are to be depended on, that the difference of longitude between Greenwich and Paris is

leſs

leſs than 9′ 25″. If we compare the obſervations made at Savile-houſe with the ſame obſervation by M. de la Lande at Paris, and reaſon in the ſame manner, we ſhall find that the difference of longitude between Greenwich and Paris muſt be leſs than 9′ 33″. Thus far, therefore, a limit, one way, is fixed for the difference of longitude between theſe two places.

The late tranſit of Venus was the only one which had ever been obſerved at Greenwich and Paris, and by comparing the obſervation at Greenwich, with that made by M. de la Lande at Paris, the difference of longitude comes out = 9′ 8″, and if we compare the obſervations at Savile-houſe (30″ of time weſt of Greenwich) with that of M. de la Lande *, the ſaid difference of longitude comes out = 9′ 16″. Since, therefore, we have only this one tranſit of Venus, by which we can determine this difference of longitude, we muſt have recourſe to the tranſits of Mercury, of which there have been four ſince the year 1723, obſerved at London, at Greenwich and at

				h	′	″
* M. de la Lande ſaw the internal contact of Venus with the Sun's limb	——	——	at	8	28	25
Père Clouet	——	——	at	8	28	26
M. Meſſier	——	——	at	8	28	27
M. Ferner	——	——	at	8	28	29
M. de la Caille	——	——	at	8	28	37½
M. Maraldi	——	——	at	8	28	42

Since, therefore, the obſervations of meſſieurs Maraldi and de la Caille differ ſo much from the obſervations of the firſt four gentlemen (who agree very nearly together) it is plain that they ought to be rejected; and indeed M. de la Caille ſays, in a letter to Dr. Bevis, that the teleſcope he obſerved with was a bad one, and conſequently his obſervation not to be depended on: M. de la Lande ſays the ſame in a letter to Mr. Maſkelyne, read at the Royal Society.

Paris.

Paris. I have, therefore, extracted from the Philosophical Transactions, and the Memoirs of the Royal Academy at Paris, the several observations of the four transits of Mercury over the Sun in the years 1723, 1736, 1743, and 1753.

The observations in the year 1723, were made by Dr. Halley at Greenwich, by Dr. Bradley at Wansted, and by Mr. George Graham at London, by messieurs Cassini, Maraldi, and De L'isle at Paris. Those in the year 1736, were made by Dr. Bevis at Greenwich, and by messieurs Cassini and Maraldi at Paris. Those in the year 1743, were made by messieurs Cassini, Maraldi, Le Monnier and de la Caille at Paris, and by Dr. Bevis and myself at Mr. Graham's house in Fleet-street, London. Those in the year 1753 were made by messieurs Cassini, Bouguer, de L'isle, Merville, Libour, le Gentil, and de la Lande at Paris, and by Dr. Bevis and myself in Surry-street, London.

By means of these observations, I have got no less than 63 determinations of the difference of longitude between the royal observatories of Greenwich and Paris, and having corrected them by parallax, they are as follows.

1723.

By the internal contact at ingress observed by Dr. Halley.

				′	″
M. Cassini	——	——	=	9	23
de L'isle	——	——	=	9	14
de L'isle	——	——	=	9	14
Maraldi	——	——	=	9	23

Dr. Bradley.

de L'isle	——	——	=	9	12
Cassini	——	——	=	9	21
Maraldi	——	——	=	9	21
de L'isle	——	——	=	9	12

Mr. Graham.

de L'isle	—— ——	——	=	8	56
Cassini	—— ——	——	=	9	5
Maraldi	—— ——	——	=	9	5
de L'isle	—— ——	——	=	8	56

12 | 110 22 | 9′ 12″

1736.

By the external contact at egress observed by Dr. Bevis.

				′	″
M. Maraldi	—— ——	——	=	9	37
Cassini, jun.	——	——	=	9	44
Cassini, sen.	——	——	=	9	14

3 | 28 35 | 9′ 31″

1743. By

1743.

By the internal contact at egress observed by Dr. Bevis.

		′	″
M. de la Caille	=	9	4, 5
Maraldi	=	9	18, 5
Le Monnier	=	8	53, 5
Cassini, sen.	=	9	33, 5
Cassini, jun.	=	9	27, 5
	5	46	17, 5
		9′	15″, 5

1743.

By the external contact at egress observed by Dr. Bevis.

		′	″
M. de la Caille	=	9	16, 5
Maraldi	=	9	36, 5
Le Monnier	=	9	23, 5
Cassini, sen.	=	9	20, 5
Cassini, jun.	=	9	42, 5
	5	47	19, 5
		9′	27″, 9

1743.

By the internal contact at egress observed by myself.

		′	″
M. de la Caille	=	8	57, 5
Maraldi	=	9	11, 5
Le Monnier	=	8	46, 5
Cassini, sen.	=	9	26, 5
Cassini, jun.	=	9	20, 5
	5	45	42, 5
		9′	8″, 5

2743. By

1743.

By the external contact at egress observed by myself.

		′	″
M. de la Caille	=	9	18, 5
Maraldi	=	9	38, 5
Le Monnier	=	9	25, 5
Cassini, sen.	=	9	22, 5
Cassini, jun.	=	9	44, 5
		5 | 47	29, 5 | 9′ 29″, 9

1753.

By the internal contact at egress observed by Dr. Bevis.

		′	″
M. Cassini	=	9	25, 5
Bouguer	=	9	6, 5
de L'isle	=	9	5, 5
Merville	=	9	1, 5
Libour	=	9	0, 5
Le Gentil	=	9	9, 5
de la Lande	=	9	3, 5
		7 | 63	52, 5 | 9′ 7″, 5

1753.

By the external contact at egress observed by Dr. Bevis.

		′	″
M. Cassini	=	9	26, 5
Bouguer	=	8	57, 5
de Lisle	=	9	7, 5
Merville	=	9	19, 5
Libour	=	9	30, 5
Le Gentil	=	9	26, 5
de la Lande	=	9	25, 5
		7 | 65	13, 5 | 9′ 19″

1753.

By the internal contact at egress observed by myself.

M. Cassini	=	9′	18″, 5
Bouguer	=	8	59, 5
de L'isle	=	8	58, 5
Merville	=	8	54, 5
Libour	=	8	53, 5
Le Gentil	=	9	2, 5
de la Lande	=	8	56, 5
	7	63	3, 5	9′ 0″, 5

1753.

By the external contact at egress observed by myself.

M. Cassini	=	9′	22″, 5
Bouguer	=	8	53, 5
de L'isle	=	9	3, 5
Merville	=	9	15, 5
Libour	=	9	26, 5
Le Gentil	=	9	22, 5
de la Lande	=	9	21, 5
	7	64	45, 5	9′ 15″, 5

The mean of the above 10 means is - = 9′ 16″, 7

The mean of the above 63 results of the difference of longitude between Greenwich and Paris is = 9 15

The

The mean of 43 results which differ not more than 15″ from the mean of the whole is ——— ——— ———	= 9′ 16″
The mean of 19 results which differ less than 15″, and more than 8″ from the mean of the whole, is —	= 9 14, 2
The mean of 24 results which differ less than 8″ from the mean of the whole is ——— ——— ———	= 9 17, 5
The mean of the above 5 means is ———	= 9 15, 8

And even the mean of those 20 results which differ more than 15″ from the mean of the whole, and which are rejected, gives the said difference $= 9' \, 12'' \frac{1}{2}$, which differing only $3'' \frac{1}{2}$ from the 43 results, is a proof of the great accuracy in the determination of the differences of longitudes by observations of the transit of Mercury over the Sun.

Let us now examine the limit of the errors in these 10 several sets of determinations, and we shall find that the limit of the errors in the year

1723 is = 27″ by the internal contact at ingress.
1736 is = 30 by the external contact at egress.
1743 is = 40 * by the internal contact at egress.
1743 is = 26 by the external contact at egress.
1753 is = 25 by the internal contact at egress.
1753 is = 33 by the external contact at egress.

* If we reject the observations of M. le Monnier, in which there seems to be some mistake, because it differs considerably from the rest, the limit of the error will be = 29″, agreeing nearly with the other limits.

From

From hence we may ſafely conclude that the difference of longitude between any two places may be determined by one ſingle obſervation of the contact of Mercury with the Sun's limb, made at each place, ſo that the error in the determination will not exceed 30″ of time from the truth: whereas in the above 33 obſervations of the eclipſes of the firſt ſatellite of Jupiter we find the limit between the errors to amount to 3′ 44″ of time. If we take a mean of the ſaid obſervations of the firſt ſatellite, the difference of longitude between Greenwich and Paris is = 9′ 29″, and if we reject thoſe which differ the moſt from the reſt, the mean of the remaining 25 obſervations gives the ſaid difference = 9′ 40″, and the mean of thoſe 8 obſervations, which are rejected, gives the ſaid difference = 8′ 53″, both which laſt determinations can be proved to be very far from the truth by the obſervations of the late tranſit of Venus; for by the ſaid obſervations of Venus it appears that the difference of longitude between Greenwich and Paris cannot exceed 9′ 33″, as I ſaid before; and if the ſaid difference is = 8′ 53″, then the parallax of the Sun, by the Savile-houſe obſervation compared with that of M. de la Lande at Paris, would amount to 20″ which we are ſure it cannot be.

Upon the whole therefore we may cnnclude, that the difference of longitude between the royal obſervatories of Greenwich and Paris (as determined by 63 obſervations of the contact of Mercury with the Sun's limb made at each place) is = 9′ 16″. This determination would have been perhaps more deciſive, if I could have had recourſe to the books containing the obſervations of the late aſtronomer royal, Dr. Bradley.

Bradley. Obſervations! made by one of the greateſt aſtronomers, and by the beſt and moſt accurate obſerver, aſſiſted by the beſt and moſt accurate inſtruments, which are in any obſervatory: But alas! the public are hitherto deprived of the uſe of theſe moſt excellent obſervations*.

In a former paper which I had the honor to give into the Royal Society, concerning the parallax of the Sun, I therein aſſumed the difference of longitude between Greenwich and Paris to be $= 9' \; 10''$; and as the determination of this difference is now more certain by the tranſits of Mercury above mentioned, being found $= 9' \; 16''$; and as this difference of longitude will make ſome ſmall difference in the reſult of the ſaid parallax from the obſervations made at all thoſe places †, which are to the eaſt of Greenwich, where the late tranſit of Venus was obſerved: I have therefore computed them again, and they are as in the following ſynoptic table.

* On Thurſday following, being the 9th of June, a motion was made, at the meeting of the Royal Society, by the Rev. Nevil Maſkelyne, F. R. S. and unanimouſly agreed to, recommending it to their Council, as viſitors of the Royal Obſervatory, to take proper meaſures for obtaining and ſecuring the aſtronomical obſervations, that have been made there in times paſt, for the benefit of the publick: It was alſo agreed on to publiſh them, when obtained, at the expence of the Society; and for the future, to publiſh the obſervations made at the Royal Obſervatory annually, in the Philoſophical Tranſactions.

† Becauſe the longitudes of all thoſe places were taken from the *Connoiſſance des Temps*, and the *Swediſh Acts*, in which their differences of longitude from Paris are marked down.

The time of the internal contact of Venus with the Sun's limb obſerved at the Cape of Good Hope compared with that at

	Sun's Parallax.	
Greenwich	= 8″, 42	1
Shirburn-Caſtle	= 8, 15	2
Savile-Houſe	= 8, 57	3
Leskeard	= 8, 69	4
Paris	= 8, 54	5
Bologna	= 8, 54	6
Rome	= 8, 74	7
Drontheim	= 8, 33	8
Upſal	= 8, 60	9
Stockolm	= 8, 59	10
Hernoſand	= 8, 78	11
Calmar	= 8, 97	12
Abo	= 8, 68	13
Tornea	= 8, 09	14
Cajaneburg	= 8, 43	15

By the mean of theſe 15 reſults, the Sun's parallax on the day of the tranſit — = 8, 54

And if we reject the 2d, 11th, 12th, and 14th, which differ the moſt from the reſt, the mean of the remaining eleven gives the Sun's parallax — = 8, 56

Therefore the mean horizontal parallax of the Sun is — = 8, 69